

## **BIOTEN General Partnership**

Subcontractor: BIOTEN General Partnership  
10330 Technology Drive  
Knoxville, TN 37932

Contracting Party: Midwest Research Institute, National Renewable Energy Laboratory  
Division

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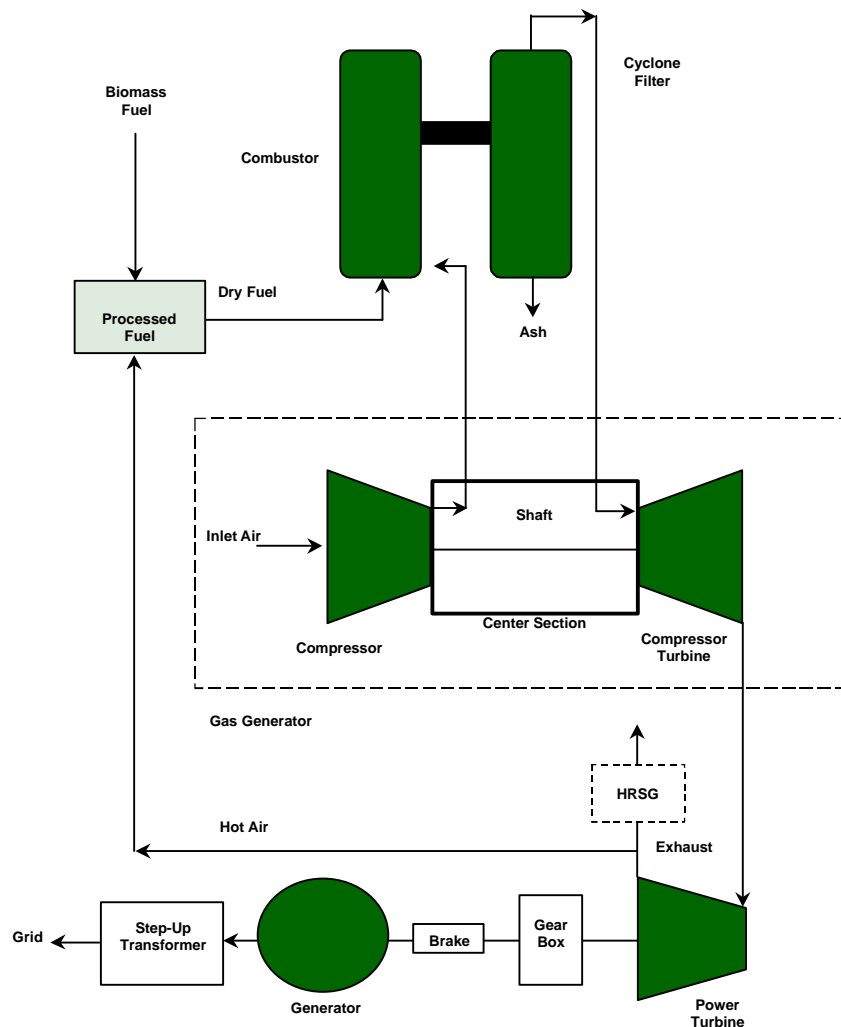
## **Introduction**

BIOTEN Corp. (BIOTEN) of Knoxville, Tennessee, is the corporate successor of BIOTEN Partnership (“BIOTEN GP”), a general partnership of BIOTEN, LLC (“LLC”) and EUA BIOTEN, Inc. (“EUA”), a wholly owned subsidiary of Eastern Utilities Associates, Boston, Massachusetts.

BIOTEN has developed a generation system that produces electricity using biomass fuels directly fired in conjunction with a combustion turbine (“BIOTEN process”). The BIOTEN process utilizes the direct firing of biomass fuel in an offset, pressurized combustor whose combustion gases are cleaned in a cyclone filter and injected into the compressor turbine. BIOTEN modifies the combustion turbine by replacing the original fuel combustion chamber with a center section. The BIOTEN process is presented in Figure 1. The box labeled “Processed Fuel” represents a BIOTEN biomass fuel processing system designed to convert the raw “Biomass Fuel” into the “Dry Fuel” or “Fuel Dust” required for the BIOTEN combustion process. The BIOTEN combustion turbine system is composed of the components identified as “Combustor,” “Cyclone Filter,” “Gas Generator,” and the “Power Turbine.” The generation of electricity involves the component “Gear Box” and “Generator.” The “Step-up Transformer” is part of the system to distribute the generated power to the power purchaser. The “Brake” is part of the safety systems built into the BIOTEN process to handle emergency situations.

The BIOTEN process has several environmental and economic advantages over the competing technologies:

- The BIOTEN process requires no process water because there is no steam cycle; thus, there is no water makeup or wastewater discharge.
- The process utilizes renewable biomass fuel, which is low in sulfur and nitrogen; thus, the SO<sub>2</sub> and NO<sub>x</sub> emissions impacts are generally less than those of fossil fuels.
- The utilization of biomass fuels results in a zero net input of atmospheric CO<sub>2</sub> to the world greenhouse gases.
- The BIOTEN process can be installed in 10 months or less.
- The BIOTEN process has a low capital cost and an efficiency that results in very competitive production costs.



## Potential Markets

This report analyzes the suitability of the BIOTEN process to be used in three countries or markets with distinctly different features. BIOTEN has performed significant research on India, the Philippines, and Canada in an effort to understand each country's market potential for applying the BIOTEN technology. We have contacted numerous prospective customers for our generating plants, including sugarmill owners, rice millers, lumber operations, paper and pulp facilities, waste disposal companies, and other biomass-related companies. The following are summaries of BIOTEN's market and resource assessments for the three countries studied.

<b>A. SUMMARY OF MARKET ASSESSMENT</b>			
	<u>India</u>	<u>Philippines</u>	<u>Canada</u>
1. Application of Bioten Process	<ul style="list-style-type: none"> <li>• Simple Cycle</li> <li>• Use of waste heat to enhance overall efficiency</li> </ul>	<ul style="list-style-type: none"> <li>• Simple cycle</li> </ul>	<ul style="list-style-type: none"> <li>• Simple cycle</li> <li>• Use of waste heat to enhance overall efficiency</li> </ul>
2. Market Size	3,500 MW	250 MW	1,000 MW
3. Module Size	3-6 MW	5-6 MW 1-3 MW	5-6 MW
4. Competing Technologies	NONE IN BIOTEN CAPACITY SIZE RANGE		
5. Permitting Requirements	BIOTEN PLANT WILL SATISFY ALL KNOWN REQUIREMENTS		
<b>B. SUMMARY OF RESOURCE ASSESSMENT</b>			
1. Feedstock Suitability	<ul style="list-style-type: none"> <li>• Bagasse is acceptable</li> </ul>	<ul style="list-style-type: none"> <li>• Rice hulls are acceptable</li> </ul>	<ul style="list-style-type: none"> <li>• Sawdust, trimmings and bark are acceptable</li> </ul>
5. Properties	CHEMICAL COMPOSITION SUITABLE		
6. Competitive Uses	<ul style="list-style-type: none"> <li>• Minimum to none</li> </ul>	<ul style="list-style-type: none"> <li>• None</li> </ul>	<ul style="list-style-type: none"> <li>• Minimum to none</li> </ul>

Other features of these markets are:

India – Must import most of its liquid fossil fuel used to produce electricity. Laws have been passed in recent years to encourage the development of private power production. Sugarcane bagasse is a by-product of the sugar manufacturing process with a small- to medium-sized sugarmill capable of producing 5 to 10 MW of exportable electricity.

Philippines – Imports most of its fuel. There are large geothermal areas but energy costs are still very high. Laws affecting the disposal of rice hulls have not been enforced because of lack of disposal areas. Availability of rice hull burning plants would encourage enforcement. In many areas, three to ten rice mills produce enough rice hulls to supply a BIOTEN plant.

Canada – The country has extensive natural resources of energy; consequently, relatively low electricity rates. However, large quantities of sawmill waste are produced and environmental laws are forcing increased costs in disposal.

BIOTEN will focus on India to develop various strategies and business relationships needed to begin to penetrate this market and to develop a model for other international markets.

## **System Design**

BIOTEN has designed and constructed a net 5.0-MW commercial demonstration plant (CDP) located at Red Boiling Springs, Tennessee. The CDP is fueled by waste fresh-cut sawdust that is abundantly available in this part of Tennessee. The CDP has gone through several phases of testing and development during the past two years. The major components, including the fuel processor, turbines, pressurized suspension combustor, and cyclones, are based on technologies that are well known and have strong performance and maintenance records with tens of thousands of hours of in-service histories. The BIOTEN basic open cycle generation system design is characterized as a 5.0-MW net output plant operating at 1400°F and 120 psig with a mass flow of about 125 pounds per second while consuming approximately 10 tons per hour of biomass. The BIOTEN process plant may be obtained including all equipment requirements from fuel receiving and processing through the utility interconnection, as required by customer specification. The plant will fit on a 3-acre site or a parcel of land approximately 300 by 400 feet in size. The construction period is approximately 10 months.

The basic open cycle configuration provides three products. The primary product is electricity. The plant's net generation can be operated as a traditional base load generation plant. A secondary product is the plant's thermal discharge that may be used for drying and/or heating processes. The third product is an ash that contains potassium and other trace elements that support photosynthesis.

The basic fuel supply will normally be a waste stream. Thus, the BIOTEN process promotes the environmentally sound disposal of biomass waste products. The use of biomass fuels will help obtain the environmental targets established through the Kyoto, Japan Agreement. The agreement requires nations, especially industrialized ones, to effect significant reductions in greenhouse gases such as methane (CH<sub>4</sub>) and CO<sub>2</sub>. The BIOTEN process will greatly reduce the agricultural waste dumpings, major sources of CH<sub>4</sub> and CO<sub>2</sub> gases through the natural decomposition process of any biomass. Furthermore, burning biomass fuels does not generate the excess CO<sub>2</sub> associated with it burning fossil fuels because biomass consumes the same amount of CO<sub>2</sub> in its growth process as it generates when burned. Potential biomass fuel sources include waste products from lumber mills, forest and right-of-way clearing operations, pulp and paper mills, sugarcane mills, rice mills, and agricultural waste such as wheat and corn stalks.

The BIOTEN process promotes the local environmental wellbeing by:

- a. Disposing of waste residues while reducing greenhouse gas emissions and landfill requirements.
- b. Reducing the need for fossil fuel by displacing some of the requirements with an inexpensive, locally generated renewable fuel source.
- c. Providing electrical and thermal energy for the industrial and manufacturing complexes and the surrounding area and does not require a large transmission facilities infrastructure.
- d. Generating a secondary product, an ash containing potassium and other trace elements, that is usable as the basis for a natural fertilizer and other commercial products. The use of an ash-based natural fertilizer will reduce the need for chemical-based fertilizers, another environmental benefit.

The CDP was sited under the State of Tennessee Environmental Siting Provisions. The Tennessee

Environmental Protection Agency (EPA) mandates emission compliance levels that are either the same as or more stringent than the United States Federal EPA requirements.

## **Future Development**

BIOTEN has some remaining challenges that need to be satisfied to allow significant penetration into India or other world markets. The CDP will be used to prove the viability of the BIOTEN technology and demonstrate its performance characteristics. BIOTEN expects that sufficient data and operating results will be obtained and analyzed during the year 2000 to allow BIOTEN to offer a commercial product on a turnkey basis with reasonable commercial guarantees for availability, heat rate, and capacity. The CDP will also allow BIOTEN to test and qualify additional biomass fuels besides sawdust including bagasse, rice hulls, and tree bark.

BIOTEN has developed an O&M plan to support the CDP, including operating procedures, preventative maintenance procedures, major overhaul schedules, and operator qualification and training programs. Additional run time at the CDP will allow BIOTEN to verify and fine tune these O&M procedures. These procedures will also provide the basis for developing the O&M support infrastructure required in foreign countries.

BIOTEN's vision of itself as a mature business focuses on providing customers worldwide with turnkey technology and customer services to support the development of renewable, clean, and economical electrical and thermal energy. To accomplish this, BIOTEN's services will include engineering, procurement, and construction (EPC) services as well as financing support and O&M support services as defined by the customer.

To achieve these goals, BIOTEN has developed the following three sets of objectives:

### **A. Corporate Objectives**

1. Build a company recognized as a competent engineering and manufacturing firm that is recognized as a leader in the biomass power generation field.
2. Establish a reputation of quickly responding to potential business opportunities.
3. Operate the CDP on a financially sound and safe basis.
4. Use the CDP to develop approaches that improve the BIOTEN technology related to plant performance, efficiency, reliability, availability, and maintainability.
5. Collect data from CDP operations to optimize the commercial design of the BIOTEN process for as many biomass fuel sources as possible.
6. Develop and maintain a corporate staff that will support the company growth.

### **B. Business Development Objectives**

1. Create and maintain an organization that provides the capability to address rapidly changing market and business opportunities.
2. Develop ongoing business relationships with renewable fuel producers, utilities, consultants, and EPC firms providing services to the electric generation market, power marketing groups,

outside financial sources, and O&M contractors to improve BIOTEN's possibility of expanding its business and satisfying customer's needs.

C. Financial Objective

1. Obtain corporate revenue stream from unit sales and the associated ancillary functions that will continuously allow the company to grow.

BIOTEN's definition of success will be based on a combination of selling BIOTEN process systems worldwide while achieving the corporate, business development, and financial objectives previously discussed. BIOTEN recognizes most of its unit sales will be foreign.

The United States has a mature electrical generation and distribution system in place. The deregulation activities will not dismantle this structure but will realign it to provide more opportunities for competition. The generation opportunities will provide BIOTEN with the niche market for its products. In some regions of the United States biomass-fueled electric generation is not feasible. However, niche markets will be created for systems in the 5-MW to 10-MW range. This is BIOTEN's target market in the United States. This market will include the lumber and forestry industries, the municipal and landfill operators seeking ways to improve their management programs to extend the useful life of their assets, and some enterprising firms that will combine many resources for the mutual benefit of all parties involved.

Foreign countries that have agricultural foundations represent the largest market opportunity for any form of biomass energy generation. The BIOTEN process will help these countries develop their local infrastructures at feasible and economic rates. Developing nations have the desire to obtain the U.S. and Western European standard of living. However, they recognize this will not happen soon and will require both careful planning and financial support.

A successful BIOTEN will possess the engineering and manufacturing capabilities to satisfy all potential customers. Additionally, BIOTEN will have developed the necessary relationships to support any client with financing, EPC, and O&M support issues as required. In terms of unit sales, a successful BIOTEN should be capable of delivering eight stand-alone units, six tandem units, four fuel processing systems, and the associate support functions per year.